Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Mining Research Laboratories

Laboratoires de recherche minière

[redacted]

Canada

PROG/17/90/04

CANMET MINING RESEARCH LABORATORIES 89/90 ENVIRONMENT-RELATED ACTIVITIES

compiled by E.D. Dainty

MRL 90-4 (OP) January 1990

This document was compiled to assist the Assistant Deputy Minister to present this subject to various audiences within and without the Energy Department

22 pp.

CANMET MINING RESEARCH LABORATORIES
89/90 ENVIRONMENT-RELATED ACTIVITIES

compiled by E.D. Dainty

SUMMARY

In response to Departmental requests, the following summary of the environment-related activities of the five Mining Research Laboratories of CANMET/EMR, has been prepared. The material includes:

(1) a summary of the MRL 1989/90 resource allocations for each laboratory,

(2) a summary of the 1989/90 resource allocations for each MRL project,

(3) a one-page description of each of the nine current projects, and

(4) a one-page transparency indicating the highlights of each project.

This material has been compiled from descriptions written by the scientists involved in each of the projects, as follows:

(1) automated mine ventilation	Mahe Gangal (CMTL/CEAL)
(2) mine ventilation science	Stephen Hardcastle (ELL)
(3) air-borne toxic dust assessment	Michel Grenier (ELL)
(4) dieselized mine air quality assessment	Mahe Gangal (CMTL/CEAL)
(5) diesel exhaust treatment device development	Don Dainty (CEAL)
(6) diesel emissions health impact determination	Don Dainty (CEAL)
(7) radiation control in mining	Jaime Bigu (ELL)
(8) sulphide dust explosion control	Ken Mintz (CEAL)
(9) mining and milling waste management	Nand Dave (ELL)

SUMMARY OF 1989/90 RESOURCES ALLOCATION FOR CANMET/MRL ENVIRONMENT-RELATED ACTIVITY

NAME OF LABORATORY	1989/90 RESOURCES			
	TOTAL		ENVIRONMENT-RELATED	
	$k	(PY)	$k	(PY)
CANADIAN MINE TECHNOLOGY (CMTL)		(27.0)	20	(0.2)
ELLIOT LAKE (ELL)		(22.0)	666	(11.0)
CANADIAN EXPLOSIVE ATMOSPHERES (CEAL)		(14.0)	592	(5.9)
CANADIAN EXPLOSIVES RESEARCH (CERL)		(14.0)	-	-
ADMINISTRATIVE UNIT		(7.0)	102	(1.4)
SUDBURY LABORATORY		(3.0)	-	-
TOTALS	$6,346k	(87.0)	$1,380k	(18.5)

PERCENTAGE OF ENVIRONMENT-RELATED MRL ACTIVITY = 22% FUNDS
21% PY

PROJECT SUMMARY OF CANMET/MRL ENVIRONMENT-RELATED ACTIVITY (1989/90 RESOURCES)

	project title	($k)	(PY)
(1)	automated mine ventilation systems	70	(0.7)
(2) (3)	mine ventilation science and air-borne toxic dust assessment	242	(4.0)
(4)	dieselized mine air quality assessment	200	(2.0)
(5) (6)	diesel exhaust treatment device development, and diesel emissions health impact determination	80	(1.3)
(7)	radiation control in mining	242	(4.0)
(8)	sulphide dust explosion control	262	(2.1)
(9)	mining and milling waste management	182	(3.0)
	sub-totals	$1,278k	(17.1)
	admin	102	(1.4)
	totals	$1,380k	(18.5)

PROG/18/90/10

TITLE: AUTOMATED VENTILATION SYSTEMS IN DIESELIZED MINES

PROBLEM: The operating costs associated with the provision of fresh air in Canadian dieselized mines are among the highest of all the mine operating costs, mainly for the reason that for a substantial portion of the year, the mine air must be heated before introduction into the mine workings. Minimizing the ventilation at levels deemed suitable for the maintenance of health, is a major goal of the industry.

BACKGROUND: Canadian mines are heavily dieselized, involving 3000 plus diesel-powered machines. Levels of several gaseous and particulate pollutants generated by these machines, demand the supply of sufficient fresh air to dilute the contaminants to non-health-impacting concentrations. Further, the ventilation costs can be reduced by the optimization of air flows in mines. Excess air, where not needed, is cost ineffective. Optimization requires a computerized system for air quality control at an economic cost.

DESCRIPTION: CANMET has undertaken various parallel studies in cooperation with mining industries which will finally lead to the development and demonstration of a partial or fully-closed-loop air quality control technology. The major elements of this ongoing work are cited as follows: (1) optimization of air flows in mines, CANMET Thermodynamic Ventilation Network simulation model and tracer gas studies, (2) assessment of various pollutants and air quality in various Canadian mines, (3) determination of a criteria for the control of air quality including the Air Quality Index and CO2 surrogate behaviour, (4) confirmation of available sensor performance by evaluation of various environmental sensors in a simulated diesel environment in the laboratory and in a production mine in 1990, (5) determination of vehicle operator exposure by vehicle-mounted CO2 radio signal sensor/transmitter, (6) ventilation recirculation feasibility studies, (7) Confirmation of operation of the CONSPEC continuous monitoring and control system (installed in an underground mine in 1988 and functioning well), (8) installation of closed-loop system (there are several potential mines for this application; implementation will require several millions dollars for several hardware, software and control technologies to be developed), (9) expert system software development to automate control if loop to be fully closed (based on toxicity criterion selected and application of engineering factors of safety), and (10) finally the completion of extended trial of complete system in a mine.

BENEFITS: (1) assurance of suitable mine air quality for workers with likely spin-off of increased production and a more stable work force (2) minimization of ventilation and heating costs for mine operators in today's competitive market (3) availability of reliable continuous records to operators and Inspectorates and (4) availability of pollutant profiles and ventilation system for research purposes.

TITLE: AUTOMATED VENTILATION SYSTEMS IN DIESELIZED MINES

ACTIVITIES:

* Demonstration of CH4/diesel continuous monitoring system
* Confirmation of available sensor performance
* Confirmation of CO_2 as a surrogate for other diesel pollutants
* Ventilation recirculation feasibility study
* Operator exposure determination by Vehicle-mounted CO_2 radio signal sensor/transmitter
* Development of continuous soot sensor
* Air Quality Criterion selection
* Installation of closed-loop system in a mine
* Expert system software development
* Hardware development for automation
* Trial of complete system in a mine

BENEFITS:

* assurance of controlled suitable air quality for workers
* increased production and a more stable work force
* savings from the reduction of ventilation costs
* reliable continuous records of environmental data for operators, inspectorates and researchers

MINE VENTILATION SCIENCE

PROBLEM: The adequacy of air supplied to perform the functions of supplying oxygen and diluting/removing pollutants, is commonly questioned. It is therefore necessary to continually to develop qualitative and quantitative methods to improve current ventilation practice and air management. Because the costs of supplying and heating air is considerable, air supply is treated as a limited resource.

BACKGROUND: The need for ventilation has been documented since Roman times. Now, a combination of main and auxilliary fans is employed to provide the desired mine air flows. Computer simulators have been available since the 1960s as an aid to air management.

Present day emphasis is placed on the optimization of ventilation, i.e. maximum air supply and efficient distribution for pollutant control at minimum cost. Such optimization studies require the capability: (a) to model and predict the sphere of influence of changes in airflow, (b) to measure a ventilation system's distribution efficiency, and (c) to quantify improvements in pollution control/reduction.

DESCRIPTION: CANMET has been responsible for both the development of mine ventilation simulation programs (CANMET's DMVNET program is widely used in Canada), and for the advancement of tracer gas/gas chromatography for assessing ventilation efficiency. CANMET/MRL, in connection with other environment-related projects, has also actively participated in the development of real-time monitors of gaseous and solid pollutants.

Incorporation of pollutant concentration prediction into computerized air flow simulation programs, is still in its infancy. Most programs are adequate only for simple air management and steady-state representations. Further improvements in pollutant prediction and air flow simulation are necessary for ultimate incorporation in programs to partially or fully-automate ventilation control systems. To contribute to these improvements, CANMET/MRL is researching the basic parameters that affect air flow at the local level.

The role of tracer gas applications in Mine Ventilation Science is gaining importance. CANMET has developed real-time single gas and multi-gas analysis systems suitable for underground use. As well as defining air flow, such systems can also supply additional information, including: air flow sources and destinations, average and total ventilation clearance times, leakage identification and quantification, and ventilation efficiency. Tracer gas may also be used as a pollutant surrogate to test the efficacy of control or dilution measures.

BENEFITS: This activity has: (1) developed a simulation model designed specifically for the multi-level mines typical of the Canadian industry, (2) demonstrated the viability and application diversity of tracer gases, both as a standard and as an investigational tool, and (3) through the combined development of modelling and tracer gas assessment, in association with improved pollutant control and monitoring, provided the mechanisms for optimizing and automating existing ventilation systems.

TITLE: **MINE VENTILATION SCIENCE**

ACTIVITIES:

(1) The continued development and promotion of computer simulation models for air distribution and air-borne pollutant variations, essential for:

* improved ventilation system planning and design
* ventilation control, increased efficiency and lower costs

(2) The development and promotion of air flow measurement techniques using tracer gases:

* providing more accurate and detailed information than present anemometric methods
* permitting measurement of air flow in otherwise inaccessible locations, such as shafts and through fans
* functioning as pollution surrogates to test control measures

BENEFITS:

improved health of miners at minimum cost due to:

* continued development of Mine Ventilation Science leading to improved pollution control strategies
* development of better models and measurement methods leading to powerful simulations, and
* high accuracy modelling, an important component of automated ventilation control systems

TITLE: **AIRBORNE TOXIC DUST ASSESSMENT**

PROBLEM: Toxic airborne particles are responsible for serious mine worker health difficulties and high medical costs to society. In addition, airborne nuisance dust hinders performance and productivity in the work place, as well as being the cause of considerable mine machinery breakdown and costly maintenance.

BACKGROUND: Regulatory Agencies and other professional societies define safe levels of exposure for toxic substances in the work place, including many dusts. As a consequence, there is a continuing need for expertise in measuring toxic dust levels in mining environments for compliance purposes. CANMET has specialized in the measurement of air-borne dust and, as a consequence, both regulatory bodies and mine operators have called on CANMET/MRL to perform dust surveys. These surveys have shown that insights regarding the dimensions of dust problems are forthcoming, in turn suggesting a variety of solutions.

DESCRIPTION: Mine operators call on CANMET as a result of Ministries of Labour and/or unions bringing health concerns to their attention. To cope with these demands, CANMET/MRL is building a sampling equipment array which make it possible to undertake large-scale dust surveys.

Airborne toxic dust assessment, when performed in conjunction with mine ventilation investigations, not only yields the concentrations of various dust components, but will also characterize the dust from the standpoints of source, size, charge, and other pertinent parameters. This type of information may then be put to use in order to select an appropriate dust control program for the circumstances.

CANMET/MRL/ELL has recently developed an air flow tunnel facility which permits the calibration and performance determination of ventilation and dust monitoring instrumentation. For example, one service that MRL/ELL offers on a cost recovery basis is quartz dust analysis. The tunnel permits the gravimetric calibration of the quartz analyzer outputs in order to better assure correct results. The tunnel has three branches which allow the performance checks to be made at three reproducible flow rates corresponding to rates encountered in underground circumstances.

The facility will be employed in the near future to experimentally confirm the performances of continuous diesel soot monitoring devices. This mine air dust component is of particular present interest to the heavily-dieselized Canadian non-coal mining industry, due to international concern regarding the toxicity of diesel soot and its appropriate acceptable level in underground workings.

BENEFITS:

(1) development of improved mine air quality dust assessment technologies, (2) development of dust and ventilation instrument calibration facilities, (3) mine air quality assessments through dust surveys, (4) suggested dust abatement measures.

PROG/17/90/03

TITLE: **AIRBORNE TOXIC DUST ASSESSMENT**

ACTIVITIES:

(1) development of improved mine air quality dust assessment technologies

* respirable vs total dust determinations
* continuous dust monitoring
* particle size, shape, charge etc.

(2) development of dust and ventilation instrument calibration facilties

* calibration of dust sampling equipment
* lab simulation of mine air flow

(3) mine air quality assessments through dust surveys

* compliance measurements
* routine quartz analysis for industry
* ventilation savings through optimization

BENEFITS:

improved health of miners due to:

* development of dust measurement instrumentation, and
* development of dust calibration facilities
* air quality assessments

TITLE: DIESELIZED MINE AIR QUALITY ASSESSMENT

PROBLEM: Knowledge of various pollutant levels generated by diesel engines in underground mines is essential for the determination and improvement of the air quality to which workers are exposed. This requires the development and application of various techniques, methodology and instrumentation to precisely measure toxic gases and soot in order to improve the mine environment.

BACKGROUND: Diesel machines are extensively used in highly mechanized Canadian mines, mainly due to greater mobility. During the operation a number of toxic gases and particulates are emitted into the mine environment, which create a health hazard to workers.

CANMET/MRL has pioneered the monitoring, assessment and development of technologies to improve the underground environment in dieselized mines in Canada over the course of the last ten years.

DESCRIPTION: CANMET/MRL has undertaken various studies in cooperation with mining industries, Government and suppliers to develop and apply technologies to improve the underground environment. The major elements of this ongoing work for instrumentation development are cited as follows : (1) acquisition and modification of instrumentation for time-weighted-average determination of diesel toxic gases and soot, (2) modification and application of instrumentation for real-time monitoring of diesel pollutants, (3) development of a five gase portable monitoring package (will also be useful to mine ventilation engineer and provincial inspectors), (4) development of soot measurement technologies, and (5) acquisition, modification and testing of various sensors for continuous monitoring systems.

The major elements for air quality assessment technologies, are as follows: (1) measurement of pollutant profiles, (2) assessment of exhaust treatment device efficiency (past CANMET field work assessment indicates soot removal of about 90% by the use of Ceramic filters), (3) determination of vehicle operator exposure (past CANMET field work indicates that operator exposure could be as high as 200% that of general mine air), and (4) measurement of CO_2 as a surrogate for other diesel pollutants (past field data indicates a good linear correlation of CO, NO, AQI with CO_2, is a prime candidate for control criterion of mine environment, and would reduce the numbers of sensors required for mine air quality automation).

BENEFITS: (1) assurance of suitable mine air quality for workers, (2) development of reliable instrumentation for ventilation engineers and provincial inspectors, (3) data, knowledge and experience gained useful for air quality control in mines, and (4) contribution to the parallel CANMET/industry program.

TITLE: **DIESELIZED MINE AIR QUALITY ASSESSMENT**

ACTIVITIES:

(1) Instrumentation Development

* Monitoring technology for TWA determination of gases & soot
* Assembly/modification of real-time monitoring system for pollutants
* Use of portable continuous monitoring devices to determine soot concentrations
* Development of portable five gases (CO, CO_2, NO, NO2 and SO_2) monitoring package
* Computerized data acquisition and analysis system for field application
* Development of soot measurement technologies

(2) Air Quality Assessment Technologies

* Field measurement of pollutant profiles
* Assessment of diesel emissions control technologies
* Determination of vehicle operator exposure
* Confirmation of CO_2 surrogate for other pollutants

BENEFITS:

* Determination of a control parameter for automated ventilation system
* Assurance of suitable air quality for workers
* Development and evaluation of better monitoring equipment
* Development of soot measurement technologies
* Increased production and a more stable work force

TITLE: DIESEL EXHAUST TREATMENT DEVICE DEVELOPMENT

PROBLEM: Development of devices for the removal or reduction of toxic pollutants present in emissions from mining diesel machinery is undertaken to protect and improve the health of miners.

BACKGROUND: Diesel engine emissions contain numerous toxic pollutants including four major toxic gases (CO, NO, NO2 and SO2), soot, unburned fuel and lubricant, aldehydes and numerous polynuclear aromatic hydrocarbons some of which are carcinogenic. Removal or reduction of these constituents increases the usefulness and productivity of a very large investment ($0.75 billion) by the mining industry in diesel machinery.

Contract studies by IW French in 1978 identified soot as the major health-impacting constituent in diesel exhaust. This lead CANMET to propose the collaborative development of soot removal devices. Ultimately, the ceramic filter and the venturi scrubber were developed in connection with this program in cooperation with the United States Bureau of Mines and the Ontario Ministry of Labour and numerous industrial partners.

Employment of these devices removes 70 to 90% of the soot and improves the overall quality of the environments in which they are employed by at least 100% as measured by the Air Quality Index (AQI) criterion.

The ceramic filtration technology has already been transferred to Engine Control Systems (ECS) of Newmarket, Ontario, and is being applied around the world. The venturi scrubber technology is in process of being licensed to the same company.

DESCRIPTION: The ceramic filtration technology developed thus far applies to "hot" machines, i.e. those with suitably high exhaust gas temperatures which result in autoregeneration of the filters. Many mining production machines are in this category. However, because of cool exhaust gas temperatures, the large surface truck and bus market requires the development of a heat augmentation system to automatically regenerate the filter when the back pressure reaches a pre-established threshold due to unburned soot deposition.

CANMET continues to work with ECS to develop such a system. A cooperative CANMET/NRC/ECS effort to demonstrate the system is likely in 1990/91. Likewise, the venturi scrubbing system is scheduled for a mine demonstration in Australia in 1990/91

BENEFITS: This activity has: (1) developed two effective emissions reduction devices. The economic benefit attributed to the filter has been estimated at $21.4 million in 1990 dollars, compared to the estimated development cost to CANMET of $1.5 million - a 14 to 1 ratio. (2) The devices provide a means of protecting mining investment in diesel technology against expected substantial reductions in allowable soot levels in mines that might otherwise have prevented the deployment of such machines. (3) They have been shown to produce at least a 100% improvement in the quality of underground mine environment.

PROG/18/90/04

TITLE: **DIESEL EXHAUST TREATMENT DEVICE DEVELOPMENT**

ACTIVITIES:

(1) **promotion of the use of emissions reduction devices** through numerous contacts with industry

(2) **projected collaboration with the USBM through a new MOU** to come into effect in the near future

(3) **demonstration of an automated regeneration system** for cool exhaust surface and mining diesel machines

BENEFITS:

* an economic benefit for Canada of 14 times the CANMET investment in ceramic filter R/D and D.

* protection of a $0.75 billion investment by the mining industry in diesel machinery

* a 100% improvement in the quality of mining environments improving the health of workers

TITLE: **DIESEL EMISSIONS HEALTH IMPACT DETERMINATION**

PROBLEM: Knowledge of the health effects of the multiple diesel pollutants continually grows and exposure levels need adjustment accordingly. This process updates the prescription of adequate underground ventilation for maintaining the health of workers.

BACKGROUND: Diesel emissions have always been objectionable, particularly when the concentrations are such that eyes water and odour overpowers, etc. In 1975, as a consequence of the first "energy crisis," it was anticipated that there would be a 1000-fold increase in diesel soot levels in ambient urban environments as a result of significant increases in the use of fuel-efficient diesel vehicles.

It was known that there were carcinogenic components in the liquid hydrocarbons generally attached to the soot particles. Quantifying soot/hydrocarbon effects, those of the gaseous pollutants, and their interactions as well, has resulted in much study of the impacts over the last 15 years. This work has confirmed CANMET's early position that soot is the major health-impacting constituent in diesel exhaust.

DESCRIPTION: CANMET has undertaken studies in three relevant areas: (1) development of the Air Quality Index (AQI) comprehensive criterion for exhaust toxicity definition, (2) Ames mutagenic assessments of engines, treatment devices and underground environments, and (3) monitoring of the levels of polynuclear aromatic hydrocarbons (PNAs) in mine air to assess their health-impacting potential.

The Air Quality Index is defined by a mathematical equation which incorporates 4 toxic gases and soot in a single expression yielding a comprehensive toxicity number used to prescribe ventilation for diesel machines according to two CSA national standards for diesel mining machines. It was also used as the criterion for judging R/D progress in the development of emissions reduction devices (ceramic filter) in cooperation with the USBM and the Ontario MOL. Ames bacteriological assessments are used routinely at low cost (relative to animal studies) to red flag new emissions equipment developments, as high Ames activity correlates with the potential to produce carcinogenic tumours. CANMET has correlated dynamometer studies with underground studies. These studies identified a potential problem with a certain brand of catalytic purifier which is now infrequently used. It has likewise been determined that PNAs would not appear to be a health concern when mine levels are compared to those in other work places.

Refinement of the AQI continues by means of contracts with I.W. French and Associates to incorporate the results of considerable recent animal studies, and promotion of the concept is being vigourously pursued.

BENEFITS: This activity has: (1) resulted in greater assurance to the industry that present mine ventilation practice, in some normal circumstances, is acceptable, (2) provided a yard-stick (the AQI) by which to gauge suitability of underground environments, (3) provided a criterion (the EQI) by which to measure emissions reduction device development progress and for diesel engine emissions certification.

PROG/18/90/02

TITLE: **DIESEL EMISSIONS HEALTH IMPACT DETERMINATION**

ACTIVITIES:

(1) **continuing development of the Air Quality Index (AQI) mine environment comprehensive pollutant toxicity criterion** - includes CO, NO, NO2, SO2 and soot

* used to quantify and confirm new emissions reduction device performance
* used to certify diesel power packages for ventilation prescription
* can be used to quantify underground environmental air quality

(2) **performance of Ames mutagenic emissions assessments**

* lab dynamometer engine/treatment device emissions results correlated with underground environment data permitting discovery of trouble by lab tests
* one such device now infrequently used as a result

(3) **performance of polynuclear aromatic hydrocarbon (PNA) assessments**

* no apparent hazard in underground mines in Canada when compared to other work places

BENEFITS:

* AQI provides a toxicity criterion for diesel engine emissions toxicity and environmental air quality
* AQI concept potentially important for simplification of imminent mine ventilation automation efforts
* health-impacting mutagen and PNA levels monitored; little apparent concern with present practice

TITLE: **RADIATION CONTROL IN MINING**

PROBLEM: The control of radiation in mines is important in order to limit the exposure of personnel to unecessaril;y high radioactivity levels. Because of this, acurrate determination of radiation levels is necessary, and hence the need for adequate calibration facilities to test and calibrate instrumentation used in the determination of radioactivity levels, and in the monitoring of these levels for radiation control purposes in the work place.

BACKGROUND: Underground mine and mill atmospheres contain significant amounts of radioactive pollutants which may pose a serious health hazard to workers. The most common radioactive pollutants found in mine atmospheres are radon and thoron gases and their decay products, and airborne dust containing long-lived radionuclides. Dust containing long half-life radioactive elements, is referred to as Long-Lived Radioactive Dust (LLRD).

The radioactive pollutant concentrations depend on environmental conditions in the mine and the type of mining operations. However, these pollutants are also found in mine atmospheres in the absence of mining activities. Hence, it is important, first, to identify the different, potentially hazardous radiation sources, and second, to develop and/or optimize techniques and methods to reduce, eliminate, or at least to control the levels of airborne radioactive pollutants. The first requires extensive radiation surveys with sophisticated instrumentation; the latter, periodic and delicate calibration procedures.

DESCRIPTION: The areas of research presently undertaken at CANMET/MRL/ELL are: (1) radiation control (radon plus its progeny, and LLRD), (2) development of radiation measurement techniques and instrumentation, (3) implementation of radon and LLRD instrument calibration facilities, and (4) radiation mine modelling.

Several measures have been used in mines to control radioactivity, including: ventilation (with and without recirculation), radon gas sealants, and a wide variety of electrostatic and mechanical methods (scrubbers and electrostatic collectors). CANMET has contributed to control measures, particularly to the last, in the form of a number of published studies. Further, CANMET/MRL/ELL has devoted considerable effort to the development of suitable radiation instrumentation (three major instruments are now used world-wide). Also, calibration facilities for radon and its progeny and LLRD have been established for some time. These facilities are the National Radon/Thoron Test Facility (NRTTF), and Long-Lived Radioactive Dust Facility (LLRDF).

Ultimately, it is important to develop mine radiation models that predict with reasonable accuracy radiation conditions in mines. The models must take into account geometrical, geophysical and physico-chemical considerations. CANMET/MRL/ELL has contributed such modelling studies to the literature and continues to emphasize this activity.

BENEFITS: (1) improved, less radioactive environments, (2) better instrumentation design and monitoring techniques, and (3) establishment of world-class calibration and test facilities.

PROG/17/90/01

TITLE: **RADIATION CONTROL IN MINING**

ACTIVITIES:

(1) **radon and LLRD control studies:**

* ventilation recirculation
* mechanical & electro-static scrubbing
* advanced plate-out techniques

(2) **instrument and measurement technology development**

(3) **establishment of instrument calibration facilities**

(4) **radiation modelling of mine atmospheres**

BENEFITS:

* improved mine environments
* more reliable methods of quantifying radiation hazards
* more accurate means of testing and calibrating instrumentation
* improved predictive power through mine modelling

TITLE: **SULPHIDE DUST EXPLOSION CONTROL**

PROBLEM: Explosions of sulphide ore dust generated by blasting in ore bodies containing high sulphide content pose a threat to the safety of miners and reduce the productivity of these mines.

BACKGROUND: The possibility of sulphide ore dust explosions has been identified as a significant problem in many hard-rock mines since the 1920's. The main problem is not usually the direct blast damage, but rather the large quantities of toxic SO_2 gas generated. Laboratory studies of this phenomenon were carried out by CANMET in the 1960's, but interest lagged until a fatality occurred in a mine in 1985. That mine organized a workshop on sulphide dust explosions the following year for the mining industry as a whole. As a result of that meeting, a Sulphide Dust Group was established, comprising representatives from the mining industry, suppliers, academics and government bodies. It has been meeting 1 - 2 times a year to review incidents, disseminate new methods of control and stimulate further research. CANMET has been an active supporter of the Group, including jointly publishing with Noranda, the proceedings of the 1986 Workshop.

CANMET has already distributed two reports of contract work. The first was a comprehensive state-of-the-art report of this field. The second was on measurement of the quantities of dust and SO_2 produced during blasting in sulphide ore bodies.

In addition, an active laboratory program has been carried out, partly in collaboration with Noranda. A new dust explosion laboratory was set up (which is used for testing the explosibility of other industrial dusts as well). The quantity of SO_2 generated by the explosion of sulphides was measured and shown to be directly related to the amount of reaction that occurred. The effects of mineralogy and particle size were determined.

DESCRIPTION: Another contract is under way to determine if it is possible to reduce the incidence of explosions by modifying the blasting patterns. The effect of scale on dust explosions, including sulphide ore dust, is being investigated under contract by Whiteshell Nuclear Research Establishment. Laboratory studies of the explosibility of pure minerals is being continued with the aim of establishing an index of explosibility of sulphide ores, as well as to evaluate means of inerting the ore dust. Support for the Sulphide Ore Group is also continuing.

BENEFITS: Knowledge of sulphide dust explosions has been disseminated throughout the mining industry and better practices to prevent these explosions have been implemented by the industry.

SULPHIDE DUST EXPLOSION CONTROL

ACTIVITIES:

1. Sulphide Dust Group
2. State-of-the-art report (contract)
3. Measurement of SO_2 and dust generated in mines (contract)
4. Improved blasting patterns (contract)
5. Scale effect of dust explosions (contract)
6. Laboratory explosion tests on dusts from mines (in-house)
7. SO_2 measurements in lab tests (in-house)
8. Effect of particle size on explosibility (in-house)
9. Development of explosibility index of sulphide ores (in-house)

BENEFITS:

1. Dissemination of knowledge to industry
2. Improved control measures to decrease incidence of explosions

TITLE: **MINE AND MILLING WASTE MANAGEMENT**

PROBLEM: The Canadian mining industry produces in excess of 500 million tonnes/annum of waste rock and tailings, the largest portion of which arises from sulphide ore operations. These sulphide-bearing wastes present a significant environmental problem in that, upon weathering, they produce sulphuric acid, which in turn solubilizes heavy metals. This leachate has been termed acid mine drainage (AMD). In Canada, there are some 14,000 hectares of AMD-generating waste rock and tailings, and rehabilitation could cost in excess of $1.5 billion over the next 15 years. Treatment systems are therefore required to ensure that effluents from tailings piles and waste rock sites do not adversely affect the surrounding environment.

BACKGROUND: The management of acid-generating sulphide wastes has long been a concern of the industry, particularly upon closeout of a mining operation. Efforts in the past decade have have emphasized the use of vegetative covers over reactive tailings sites. While this approach improves the aesthetics and surface stability, the sites have continued to generate AMD. Hence it has been necessary to continue to operate treatment facilities long after the cessation of mining activities imposing an undesirable, indeterminate financial burden.

DESCRIPTION: In response to the evident need to develop appropriate AMD technologies, the Mine Environment and Neutral Drainage Program (MEND) was established to undertake R/D with the following objectives:

(1) to provide a comprehensive basis for the prediction of long-term management requirements for reactive tailings and waste rock, and
(2) to determine and implement techniques that permit the abandonment sites oin a predictable, affordable, timely and environmentally acceptable manner.

In order to meet these objectives, a research plan has been developed composed of the following elements:

(1) **prediction** - will the particular site generate an AMD problem? Mathematical models will be developed to aid in the evaluation of remedial systems,

(2) **prevention & control** - prevention of access of O2 without which the acid cannot be formed,

(3) **treatment** - development of passive systems to ameliorate residual acidity and precipitate and stabilize heavy metals,

(4) **monitoring** - development of consistent and reliable monitoring techniques and establish closure criteria, and

(5) **technology transfer** of the results of the program.

BENEFITS: The program will develop new, cost-effective close-out technology allowing mine operators to rehabilitate waste rock and tailings impoundments and walk-away in the knowledge that the environment will be protected in the long-term.

PROG/17/90/02

TITLE: MINE AND MILLING WASTE MANAGEMENT

ACTIVITIES:

(1) development of wet barriers (such as wet lands) on acid-generating pyritic tailings to:

* act as an oxygen barrier to control acid generation,
* stabilize the surface, and
* minimize surface and ground water contamination, and

(2) development of a contaminant migration monitoring program, data base and predictive model to evaluate various management options and scenarios over the long term

BENEFITS:

Development of new cost-effective close-out technology which will enable the operaton and abandonment of acid generating tailings and waste rock disposal areas in a predictable, affordable and environmentally acceptable manner.